Idaho Water Resources Research Institute
Annual Technical Report
FY 2008

Introduction

The Idaho Water Resources Research Institute (IWRRI) was created by the Idaho Legislature in 1963 and is administered by the University of Idaho, with its administrative offices housed on the University of Idaho - Boise Center Campus. IWRRI is dedicated to supporting and promoting water and water–related research, education, and information transfer throughout the state of Idaho. IWRRI collaborates with researchers and educators from all Idaho state supported universities; staff of local, state, and federal agencies; tribal nations; and private water interests.

The IWRRI is the only mechanism in the state that provides an autonomous statewide source of support for water research and training without regard to specific topic or discipline area. This is important because Idaho's water problems cross multiple topics and disciplines and compartmental approaches to these problems have proven to be less effective in the past. IWRRI is relied upon by state and federal agencies, tribal governments, private water interests and Idaho governmental representatives to provide the objective expertise to address water resources information needs within the state and region.

The Institute has been a strong proponent of education and outreach for both youth and adult audiences. It is through education that the public can make informed public policy decisions concerning water. It is also through education that individual citizens become engaged in the process through adjustments of their own attitudes and lifestyles.

Research Program Introduction

The Idaho Water Resources Research Institutes research program is comprised of the following objectives: (1) To work with state and federal agencies and non−government organizations to identify water research needs of the state, region and nation; (2) To promote water−related research relevant to state, regional and national needs; (3) To stimulate, coordinate, and provide leadership for water resources research within Idaho universities and collaborate with peer institutions in adjoining states; (4) To cooperate with and assist state and federal agencies and non−governmental organizations for the benefit of the citizens of Idaho, the region and the nation; (5) To encourage and facilitate public involvement in water resource research programs within the state; and (6) To develop funding for needed research and encourage cooperation with other research organizations.

The projects funded during the 2008 104B Program Fiscal Year spanned the range of water issues facing the State of Idaho. These projects addressed a wide range of physical, engineering and social science topics related to water quantity and quality issues across Idaho's diverse geography. This includes projects that investigated: a novel methodology for enhancing surface water quality in lakes subject to increased nutrient loads in northern Idaho; the regional economic demand for irrigation water in Idaho's Eastern Snake River Plain in southern Idaho; the impacts that climate change may have on the Snake River Plain's surface & ground water resources in southern Idaho; ; and the sinks for metaloids in mining-contaminated soils in the Coeur d'Alene basin in northern Idaho.

Award No. 04HQAG0205 Initial Model Development of the Spokane Valley Rathdrum Prairie Aquifer Project

Basic Information

Title:	Award No. 04HQAG0205 Initial Model Development of the Spokane Valley Rathdrum Prairie Aquifer Project
Project Number:	2005ID71S
Start Date:	7/20/2004
End Date:	9/30/2008
Funding Source:	Supplemental
Congressional District:	
Research Category:	Ground-water Flow and Transport
Focus Category:	Groundwater, Models, None
Descriptors:	
Principal Investigators:	Gary Steven Johnson, Bryce Contor

Publication

1. Hsieh, P.A., M. Barber, B. Contor, A. Hossain, G. Johnson, J. Jones, and A. Wylie. 2007. Ground-Water Flow Model for the Spokane Valley-Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties, Idaho. USGS Scientific Investigations Report 2007-5044
2. Murray, L., 2007. Boundary Condition Refinement and Quantification of Water Exchange Incorporating Long Term Variability of Perimeter Lakes with the Spokane Valley Rathdrum Prairie (SVRP) Aquifer. M.S. Hydrology thesis on file with the University of Idaho Library, Moscow, ID.

Final REPORT: U.S. Geological Survey 104b Program
2005ID 71S: Award No. 04HQAG0205 – Initial Model Development of the Spokane Valley – Rathdrum Prairie Aquifer Project

Project Summary

This project was completed in September, 2005. The project final report was submitted to the USGS Water Resources Division Office in Boise Idaho in 2005. The summary provided in the final report is as follows:

GENERAL DESCRIPTION

This Cooperative Agreement was established to provide the Idaho Water Resources Research Institute with funding to become involved in initial efforts on the Spokane Valley – Rathdrum Prairie Modeling Project. This project is a collaborative effort of the USGS, the states of Idaho and Washington, and others. This initial stage was comprised of largely a planning effort, and the overall project was completed during calendar year 2008.

There were three specified tasks in the Cooperative Agreement. The following discussion provides a summary of how these tasks were addressed and potentially evolved in the project period. These tasks are intimately connected, so a complete separation of activities is not possible. Also provided are estimates of the funding expended on each of the tasks.

TASK A

Compile and review existing ground water/surface water models for the study area: conduct preliminary model runs using existing ground water/surface water models to evaluate model conceptual elements (boundary conditions, recharge and discharge, etc.); and identify additional data requirements.

A complete set of documents describing existing models in the Spokane Valley and Rathdrum Prairie has been assembled and reviewed. The Buchanan (1999) model has been the focus of our work because the model extent is similar to the scale of the present investigation. The Buchanan model has been run by all partners in the effort including IWRRI. This model has been selected as the basis from which the new model will evolve. Several steps in that evolution have already occurred in the partnership. Those steps include: a) conversion to operate in MODFLOW 2000, b) extension of the model domain to cover all areas of interest, c) refinement of the model grid, d) distribution of Buchanan aquifer properties and recharge and discharge to the new grid, e) conversion of lakes from fixed head to "river" cells, f) adjustment of aquifer thickness to represent present estimates. In the process of performing initial model runs, the modeling team (including IWRRI) has made assessments and recommendations of additional data requirements.

This task was also amended to include initiation of a review of the interconnection and flux between the aquifer and 9 lakes along the perimeter. A graduate student has been assigned to conduct the evaluation. Pressure transducers have been deployed in most of *the lakes and in nearby wells. The program procedures have been reviewed by the Modeling Team and some existing data analysis is underway.*

Estimated Expenditures on Task: $27000

TASK B
Work with project partners to help to determine data requirements for numerical model development. Data requirements will include the collection of historical data and the collection of new field data. These data requirements will be meant to serve the needs of the ground water modeling task as well as more general project needs.

The IWRRI researchers have been working with the rest of the modeling team to identify future data requirements. Part of this effort is associated with performing preliminary model runs to gain an improved understanding of data deficiencies, consequently there is overlap between this task and the first task. Data deficiencies have been discussed in video and phone meetings with the rest of the Modeling Team and have been transmitted to the Program Technical Leadership Team(PTLT) in writing. The PTLT has been responsive and has also requested Modeling Team input on other data collection suggestions. The Modeling Team (including IWRRI) has responded.

Estimated Expenditures on Task: $7840

TASK C
Work with project partners to develop an FY05-07 work plan for developing a ground water/surface water model for the SVRP study area. This task will include meeting with project partners and interested constituents to determine modeling requirements and to determine what questions are to be addressed via ground water modeling so that the planned ground water/surface water modeling effort addresses project needs to the fullest extent possible. The SVRP Modeling Team will select the modeling code(s) to be used, and the modeling work plan will address both steady state and transient versions of the ground water/surface water model.

There have been multiple iterations on a modeling work plan within the modeling team. Within the process the roles of team members has become more refined. A draft work plan was submitted to the PTLT for comment. Those comments were subsequently addressed by the Modeling Team. The work plan continues to evolve as the project progresses. It has been developed such that modeling efforts will be complete in December 2006. It has been determined within the Modeling Team that MODFLOW 2000 will be used and that PEST will be applied to parameterize the model. The steady state model is under active development, efforts on the transient model (1995-2005 calibration period) will follow.

Estimated Expenditures on Task: $7839

Since the completion of this project the University of Idaho and the Idaho Water Resources Research Institute have been engaged in continued efforts on the development and application of the Spokane-Valley Rathdrum-Prairie Model. With funding from the U.S. EPA through the Idaho Department of Water Resources, the Institute continued in its partnership with the Washington Water Institute, the U.S. Geological Survey, the Idaho Department of Water Resources, and the Washington Department of Ecology. As a result of this effort a Modflow ground water flow model was developed and calibrated and documented in the final report *Ground-Water Flow Model for the Spokane Valley-Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties*, *Idaho* (USGS Scientific Investigations Report 2007-5044), by Paul Hsieh, Michael Barber, Bryce Contor, Akram Hossain, Gary Johnson, Joseph Jones, and Allan Wylie. A second follow-up project again developed through EPA funding through the Idaho Department of Water Resources and the Washington Department of Ecology has jointly engaged the Washington and Idaho Water Institutes in model applications and is on-going.

Publications Resulting From the Project

The final project report and a M.S. thesis were partially the result of this project.

Hsieh, P.A., M. Barber, B. Contor, A. Hossain, G. Johnson, J. Jones, and A. Wylie. 2007. *Ground-Water Flow Model for the Spokane Valley-Rathdrum Prairie Aquifer, Spokane County, Washington, and Bonner and Kootenai Counties, Idaho.* USGS Scientific Investigations Report 2007-5044

Murray, L., 2007. *Boundary Condition Refinement and Quantification of Water Exchange Incorporating Long Term Variability of Perimeter Lakes with the Spokane Valley – Rathdrum Prairie (SVRP) Aquifer.* M.S. Hydrology thesis on file with the University of Idaho Library, Moscow, ID.

The model application projects which were outcomes of this work will result in several IWRRI publications and a journal article. These are presently at the early stages of preparation.

Undergraduate and Graduate Student Researchers Supported on the Project

Ms. Lindy Murray, a MS Hydrology student at the University of Idaho was partially funded under this project. Ms. Murray completed her MS Thesis titled: *Boundary Condition Refinement and Quantification of Water Exchange Incorporating Long Term Variability of Perimeter Lakes with the Spokane Valley – Rathdrum Prairie (SVRP) Aquifer.*

Wetlands as Sinks for Metal(loid)s in Mining-contaminated Coeur d Alene Basin Soils

Basic Information

Title:	Wetlands as Sinks for Metal(loid)s in Mining-contaminated Coeur d Alene Basin Soils
Project Number:	2007ID72B
Start Date:	3/1/2007
End Date:	9/30/2009
Funding Source:	104B
Congressional District:	First
Research Category:	Water Quality
Focus Category:	Geochemical Processes, Wetlands, Water Quality
Descriptors:	
Principal Investigators:	Matthew Morra

Publication

Statement of Regional or State Water Problem

During the first two-thirds of the 20th century mining in northern Idaho produced over 31 100 metric tons of silver and 7.26 million metric tons of lead (Hoffman, 1995), with much of this activity taking place along the South Fork of the Coeur d'Alene (CDA) River in a region known as the Silver Valley. Wastes from mining and ore-processing activities were disposed directly into the South Fork of the CDA River, resulting in discharge estimates of mine and mill slimes of over 2 000 metric tons per day in 1964. Until the establishment of tailings ponds in 1968, mine tailings containing high concentrations of Pb, Zn, As, and other trace elements accumulated in stream banks or bars along the river. This material was subsequently transported by river flow and flood events, and distributed throughout the lower CDA River floodplain (Bender, 1991). Although mining activities and mining discharges are minimal today, erosion and flood events continue to suspend and transport contaminated material throughout the floodplain and into Lake CDA. Remediation options for 3,800 km^2 of the CDA River floodplain do not include contaminant removal and burial in an EPA-approved site; therefore management of the contaminated lands to decrease negative environmental impacts is the only option.

Statement of Results or Benefits

Our overall goal is to suggest management strategies for contaminated floodplain soils that will decrease the mobility and bioavailability of harmful metal(loid)s. We ultimately wish to 1) determine if wetlands in metal(loid)-contaminated areas can be used as contaminant sinks, 2) delineate spatial and temporal variables that control the extent of metal(loid) sequestration, and 3) elucidate the responsible biogeochemical processes. Studies as proposed here are the first step in determining whether the creation of wetlands might be used to sequester metals, thereby preventing dispersal in the environment. We fully acknowledge that more extensive studies will be necessary to accomplish this goal in its entirety, but view this funding request as key in developing the data set that will allow us to submit future and much larger funding requests to other granting agencies.

Nature, Scope, and Objectives of the Project

Our recent investigations indicate that continuously reduced sediments of ponds located in CDA River flooplain tailings contain soluble metal(loid) concentrations far less than similarly contaminated lake sediments experiencing active redox cycling (Toevs et al., 2006). Analyses of plant tissues obtained from aquatic macrophytes within these ponds have confirmed that this stable redox environment decreases metal(loid) bioavailability (unpublished data). However, in preliminary investigations we observed that seasonal redox changes occurring in surrounding agricultural fields appear to mobilize metal(loid)s such that pond waters experience severe contaminant inputs during the spring (Toevs, 2006). We propose that ponds strategically placed with respect to hydrologic gradients might be used as sinks to sequester metal(loid)s released from contiguous agricultural fields, thus decreasing contaminant mobility and bioavailability. Our objective is to determine the potential for ponds located within the floodplain of the CDA River to act as a sink for Cd, Zn, As, Cu, and Pb mobilized during seasonal changes in soil redox conditions. We will achieve this goal by characterizing changes in soluble metal concentrations in three ponds located in the contaminated floodplain during the course of one calendar year. We will conduct our research in metal(loid)-contaminated areas located in the CDA Mining District of northern Idaho, an area in which we have established sampling sites, substantial background data, and access to private property. The collected data will be used to support future and much larger funding requests to conduct more extensive studies in which we will elucidate the fundamental biogeochemical and physical processes controlling metal(loid) partitioning and transport in these contaminated landscapes.

Methods, Procedures and Facilities

Field Sites. Our original sample site was chosen in the center of a wetland located on Mike Schlepp's farm near Medimont, Idaho. The owner of the surrounding farm ground indicated the site has been continuously inundated since the early 1900's when the Post Falls dam was constructed. The water depth fluctuates from 1 m in the early spring, to 2 m throughout the summer, and decreases to 1 m again in the late fall. In order to replicate our studies, we will select two additional ponds that are readily accessible and behave in a similar hydrologic fashion.

Materials. All chemicals will be reagent grade and used without further purification. Solutions will be prepared using distilled, deionized water. All sampling containers and labware will be cleaned with 2% HCl, soaked in 1% HNO_3, and thoroughly rinsed with deionized water prior to use. Analytical standards and quality assurance standards for ion chromatography (IC) and inductively coupled plasma-atomic emission spectroscopy (ICP) will be purchased. Standard Reference Material 2711 from the National Institute of Standards and Technology (Gaithersburg, MD) will be used as the total metals standard for the acid digests. Acids used for total metals will be trace-metal grade (Fisher Scientific, Pittsburgh, PA).

Sediment Cores. Sediment cores will be collected in polycarbonate tubes with a diameter of 10 cm and a length of 50 cm. The tubes have been modified to securely attach to a coring device by drilling a 1-cm hole through the tube diameter and inserting a 1-cm by 12-cm head bolt secured with a hair-pin clip to an insertion assembly attached to sections of quick connect core tube extensions (AMS, American Fall, ID). The core tube extensions allow adjustment for the depth of the overlying water. Once the core tube is secure, a rope (1 m longer than the length of the steel tubing) with a traveling air-tight piston attached is fed through the open end of the core tube, through an opening in the insertion assembly, and secured to the end of the steel tubing to allow easy access. The entire coring device is then lowered in a vertical fashion until contact with the sediment is made. The core tube is then pushed into the sediment while simultaneously pulling the rope, which in turn pulls the air-tight piston. When the piston has traveled the length of the core, the device is returned to the surface in a vertical motion, with the air-tight piston holding the core in place. As the lower end of the core clears the surface of the water, a Fernco style Quickcap (Davison, MI) will be placed over the exposed end and secured. The insertion assembly is then removed from the upper end of the tube, the air-tight piston is removed with care taken not to elongate the core, another Fernco-style Quickcap is placed and secured, and the holes used to insert the headpin are covered with duct tape to prevent spillage and to maintain the redox condition of the core. The cores will be stored on ice under N_2 until they are sectioned in an anaerobic glovebox in the laboratory. Throughout the core retrieval, storage, and transport processes every effort will be made to maintain a vertical orientation. Once in the laboratory, the cores will be transferred to an N_2-filled glove box and extruded from the coring tubes with care taken to avoid compaction or elongation. Cores will sub-sectioned at the appropriate depths and homogenized samples placed in acid-washed HDPE vials. The vials will be frozen until analysis.

Overlying water samples were collected by submerging acid-washed and rinsed, 250-mL HDPE bottles beneath the water surface, removing the cap, and allowing the bottle to fill. The water samples will be immediately transferred to the processing site where they will be syringe-filtered with a 2-µm membrane and preserved for analytical analysis by adding 15-mL of the sample to an HDPE vial acidified with 0.075 mL of trace metal grade HCl to maintain a pH of less that 2.5 in preparation for metal(loid) analysis by ICP-AES or ICP-MS. All samples will be stored on ice until returning to the laboratory where they were maintained at 4°C until analysis.

Analytical Methods. Frozen, homogenized core sub-sections will be thawed, transferred to acid-washed crucibles, and dried at 90 °C until stable weights were achieved. The dry samples will be cooled in a vacuum desiccator, ground with a mortar and pestle, transferred to 10-mL polyethylene vials, and stored in a vacuum desiccator except when removed to transfer an accurately weighed sample to a container for mailing to ACME Analytical Laboratories in British Columbia, Canada.

Dissolved trace-metal analyses will be performed on a HP 4500 ICP-MS with a flow rate of 0.5 mL min^{-1} and a dilution of 5:1 via peristaltic pumps. The reported concentrations will be the average of three replications from each sample. In order to avoid airborne contamination, ICP-MS sample preparation will take place in a positive-pressure clean hood and the auto-sampler was housed in a HEPA enclosure. The RSD, as determined by running a standard 10 times, calculating the average, and dividing it into the standard deviation, will be determined. Standards will be run every 15 samples to verify calibration and will also included in the unknowns to monitor drift. Detection limits will be calculated at two times the standard deviation of the low standard.

Deployments. To meet the objective of monitoring contaminant stability under varying redox conditions, a sampling sequence will be established to capture changing pond conditions. The first water collection will take place in June 2007 and continue monthly through June of 2008. Sampling through the ice will be necessary during the winter months.

Related Research

In 2000 we began defining the biogeochemical reactions controlling toxic metal(loid) cycling within sediments of Lake CDA. One of the major concerns is that eutrophication will potentially release metal(loid) contaminants (Woods and Beckwith, 1997) by eliminating the oxic zone present at the sediment water interface. It is proposed that suboxic and anoxic conditions will promote reductive dissolution of solid materials that currently scavenge metal(loid)s and prevent them from entering the overlying water.

Sediments from Lake CDA were collected as cores and interstitial water samples obtained using equilibrium dialyzers. Solid phase associations of Fe, S, and As were probed using x-ray absorption (XAS) spectroscopy. In Lake CDA sediments we identified a gradient from oxic conditions at the sediment-water interface to anoxic conditions below 10 cm, thus creating a dynamic redox environment that controls metal(loid) sorption and solubility (Toevs et al., in review; Toevs et al., 2006). The oxic cap at the sediment-water interface traps many of the contaminant metal(loids) decreasing their flux into the overlying water column. However, flood events bury the oxic cap materials transitioning them to a suboxic zone in which reductive dissolution of the oxides releases metal(loid)s into the sediment interstitial water. High Fe:S ratios inhibit the formation of metal(loid)-containing sulfide precipitates in the anoxic zone, thus resulting in chronically and acutely toxic concentrations of soluble metals within the sediment interstitial water (Toevs, 2006).

Our goal in subsequent research was to first locate a small body of water contaminated by mine waste similar to that contained in Lake CDA sediments, but possessing an oxic interface for only a portion of the year. The interstitial water was to be monitored through an annual cycle to determine concentration changes of dissolved metals, and therefore the effect redox changes had on mine-waste stability. Because of extensive contamination and the presence of numerous wetland areas, the lower CDA River floodplain was a suitable area to consider for a monitoring site.

A pond was located with similar solid-phase contamination as found in the Lake sediments. We monitored dissolved metals in the interstitial water during an annual cycle by analyzing seasonal samples collected with equilibrium dialyzers. Surface and bottom water samples were also collected and analyzed. The analytical results were unexpected as all monitored, dissolved trace-metal concentrations in the interstitial water were lower than levels observed in Lake CDA porewater. Dissolved Pb in the pond sediments was only 7.1% that found in the lake sediments, 10.10 and 141.9 µg L^{-1}, respectively, and Zn was only 3.5% of the Lake maximum, 18.88 and 530.5 µg L^{-1}, respectively. However, Zn concentrations in the surface water of the pond experienced shifts covering two orders of magnitude, 78 to 8 688 µg L^{-1}, respectively, and the bottom water concentrations were typically greater than those found in the Lake (Toevs, 2006). When compared to Lake Coeur d'Alene, conditions in this mine-waste impacted pond increased some dissolved metal concentrations in the overlying water, but substantially lower concentrations of dissolved metals were found in the sediment interstitial water. This study therefore strongly implicates reductive dissolution of the oxic cap when buried by additional sediment as the source of dissolved contaminants in the Lake sediments and confirms the paramount importance of minimizing future transport of mine-waste sediments to the lake. Constantly saturated wetlands within the Basin do not maintain an oxic sediment cap and concentrations of metal(loid)s in sediment interstitial waters are consequently much lower than those in Lake CDA sediments. Our previous research thus indicates that pond sediments may actually be a sink for metal(loid)s, thus leading us to the research proposed here.

Training potential

One M.S. graduate student will work on the project. The Department of Plant, Soil and Entomological Sciences will provide a partial stipend for the student. We also anticipate the participation of undergraduate students in Environmental Science. These students will work on the project as part of their senior thesis project requirement. Two students worked on a similar project involving our work in the Coeur d'Alene Basin the spring of 2006.

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Woods, P.F. and Beckwith, M.A., 1997. Nutrient and Trace-Element Enrichment of Coeur d'Alene Lake, Idaho, USGS Water-Supply Paper 2485, pp. 129. U.S. Geological Survey.

Investigator’s qualifications

Matthew J. Morra
Professor of Soil Biochemistry

<u>Education/Experience</u>

Affiliate Professor, CATIE (Centro Agronómico Tropical de Investigación y Enseñanza), Turrialba, Costa Rica, 2001-present
Visiting Professor, Plant Industries, CSIRO, Canberra, Australia, 2000
Soil & Land Resources Division Chair, University of Idaho, 1999-present
Professor of Soil Biochemistry, University of Idaho, 1997-present
Associate Professor of Soil Biochemistry, University of Idaho, 1992-1997
Assistant Professor of Soil Biochemistry, University of Idaho, 1986-1992
Ph.D., Agronomy (Soil Biochemistry), 1986, Ohio State University, Columbus, OH
M.E.M., Environmental Management, 1982, Duke University, Durham, NC
B.A., Biology, 1981, College of Wooster, Wooster, OH

<u>Peer-Refereed Papers (total of 59)</u>

Toevs, G., M.J. Morra, M.L. Polizzotto, D.G. Strawn, B.C. Bostick, and S. Fendorf. 2006. Metal(loid) diagenesis in mine-impacted sediments of Lake Coeur d’Alene, Idaho. Environ. Sci. Technol. 40:2537-2543.

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Book Chapters

Morra, M.J. 2002. Assessment of extracellular enzymatic activity in soil. pp. 597-603. In C.J. Hurst, R.L. Crawford, G.R. Knudsen, M.J. McInerney, and L.D. Stetzenbach, (ed.) Manual of environmental microbiology, 2nd ed. American Society for Microbiology, Washington, DC.

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Investigating Mechanisms by Which Long Distance Circulation (LDC) Enhances Surface Water Quality

Basic Information

Title:	Investigating Mechanisms by Which Long Distance Circulation (LDC) Enhances Surface Water Quality
Project Number:	2008ID129B
Start Date:	3/1/2008
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	First
Research Category:	Water Quality
Focus Category:	Toxic Substances, Surface Water, Water Quality
Descriptors:	
Principal Investigators:	Frank Wilhelm

Publication

1. Adams, C. J. And Wilhelm, F. M. 2009. The vertical and horizontal distribution of zooplankton populations in response to mechanical circulation of water for a whole-lake management strategy. Abstract accepted for presentation at North American Lake Management Society Annual Meeting Oct 27-31.
2. Wilhelm, F. M. and Adams, C. J. 2009. Willow Creek 2008 data review. Interim progress report prepared for SolarBee Inc. and US Army Corps of Engineers, Portland District.

Investigating mechanisms by which long distance circulation (LDC) enhances surface water quality

Basic Information

Title:	Investigating mechanisms by which long distance circulation (LDC) enhances surface water quality
Project Number:	
Start Date:	29, Feb, 2008
End Date:	28, Feb, 2010
Funding Source:	104B
Congressional District:	1
Research Category:	Water Quality
Focus Category:	TS, SW, WQL
Descriptors:	Harmful algal blooms, Water quality, long distance circulation, enclosure experiments.
Principal investigators:	Frank M. Wilhelm

Publication:

Wilhelm, F. M. and Adams, C. J. 2009. Willow Creek 2008 data review. Interim progress report prepared for SolarBee Inc. and US Army Corps of Engineers, Portland District.

Adams, C. J. And Wilhelm, F. M. 2009. The vertical and horizontal distribution of zooplankton populations in response to mechanical circulation of water for a whole-lake management strategy. Abstract accepted for presentation at North American Lake Management Society Annual Meeting Oct 27-31.

Title: Investigating mechanisms by which long distance circulation (LDC) enhances surface water quality

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Project Summary:

Surface water is an important resource in Idaho with multiple uses including drinking water and irrigation supply, generation of electricity, habitat for aquatic biota including fish, and various recreational opportunities. Many of these uses can be impaired by blooms of cyanobacteria, small algae, which form surface sums and produce toxins. Harmful algal blooms (HABs) have resulted in the death of livestock, pets, wildlife and even humans; and caused authorities to close entire lakes, resulting in economic loss and reduced property values. The prevention and remediation of HABs is a high priority among lake and drinking water managers.

The proposed research aims to use an experimental approach to examine mechanisms by which long distance circulation (LDC), a newly developed method that physically moves water horizontally and vertically, controls and prevents HABs. LDC is attractive because it does not use chemicals, does not restrict water use and is solar powered. The goal of the research is to address the hypotheses that i) LDC supplies sufficient nutrients to maintain edible phytoplankton that promote a high abundance of large zooplankton, which effectively graze cyanobacteria to prevent blooms; and ii) LDC disrupts cyanobacteria from their optimal habitat at the lake surface and thus prevents blooms.

In 2008, two SB 10,000 circulators were installed in Willow Creek Reservoir (Figure 1), as recommended by the company SolarBee. One circulator was installed at the mouth of Balm Fork Arm as a barrier while another circulator further up the arm was designated as the experimental unit and was destined to treat the entire arm of the reservoir (each unit treats 35 acres). This design differed from that originally proposed because the company engineers felt that operation in U-shaped enclosures would not accurately represent lake conditions. Thus the Willow Creek Arm was to serve as a control, while the Balm Fork Arm was to be the treatment.

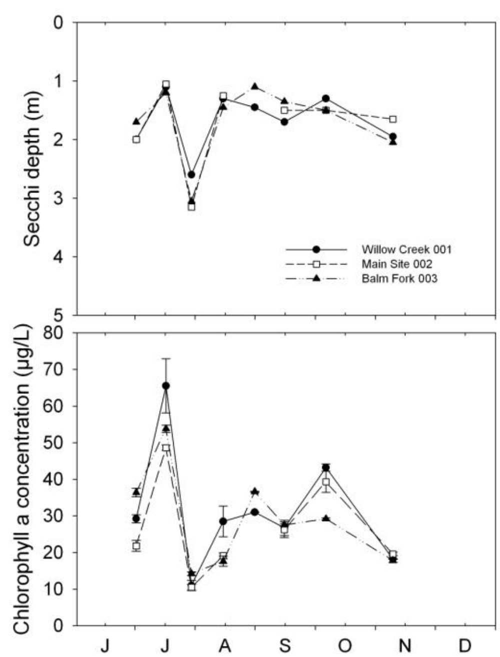
Sampling in 2008 was carried out at three sites in the reservoir, one in Willow Creek (WC 001), one at the USACE regular sampling site (MS002) and one in the Balm Fork arm between the two circulators (BF003). At each site, triplicate samples for the analysis of water chemistry, chl a, zooplankton and phytoplankton were collected.

Unfortunately, no large differences in any of the parameters measured were found between sites (Figures 2 and 3) indicating that the circulators had no effect on algae and cyanobacteria in the lake. Failure of treatment effect was partly ascribed to the prevailing winds and bathymetry of the reservoir by SolarBee. Because strong summer winds thoroughly mix surface waters among both arms of the reservoir, the circulator at the mouth of the arm could not prevent the surficial mixing as originally thought. Thus for 2009, SolarBee proposed to treat the

entire lake with eight SB 10,000 units. The effect of this treatment is currently being investigated using large exclosures that exclude part of the lake from the circulator treatment.

Figure 1. Aerial view of Willow Creek Reservoir showing location of SolarBee circulators (green points) in the Balm Fork arm, and the three sampling sites used by University of Idaho researchers.

Figure 2. Secchi depth (top) and chlorophyll a concentration at three sites in Willow Creek Reservoir during the 2008 experimental period. Bars represent ± standard error.



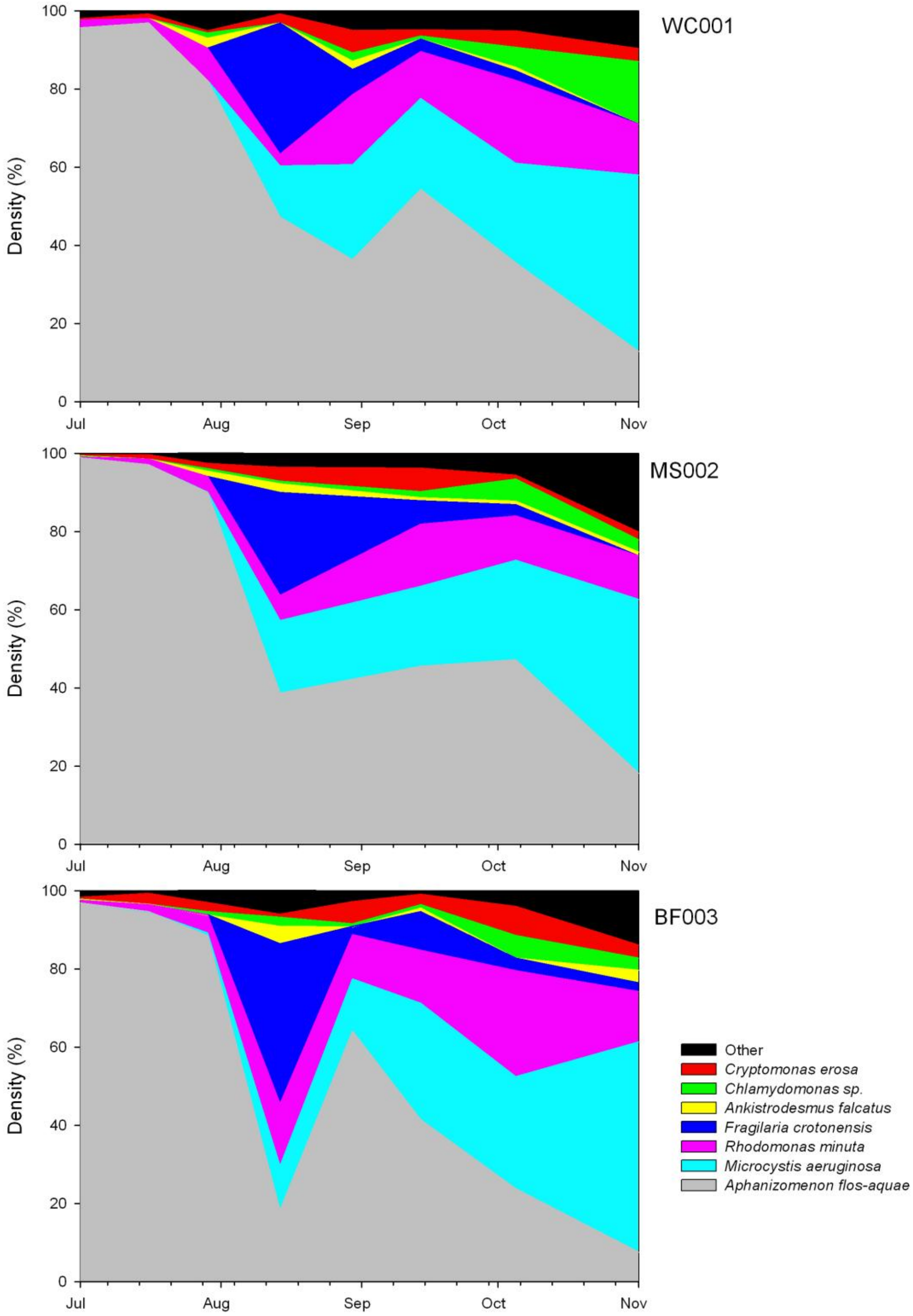


Figure 3. Phytoplankton composition at three sites in Willow Creek Reservoir during the 2008 experimental period.

Publications Resulting from the Project:

Adams, C. J. And Wilhelm, F. M. 2009. The vertical and horizontal distribution of zooplankton populations in response to mechanical circulation of water for a whole-lake management strategy. (Abstract accepted for oral presentation at North American Lake Management Society Annual Meeting Oct 27-31.)

Wilhelm, F. M. and Adams, C. J. 2009. Willow Creek 2008 data review. Interim progress report prepared for SolarBee Inc. and US Army Corps of Engineers, Portland District. (Published).

Undergraduate and Graduate Student Researchers supported on the project

Cindy J. Adams - MS Environmental Sciences - in progress
Leah Arenson - Research Experience for Undergraduates (REU) - completed

Notable Achievements or Awards

Cindy J. Adams has received 2 scholarships related to her thesis project on this grant. i) Environmental Science Program Graduate Interdisciplinary Enhancement Fund (GIEF); and ii) Braatne Memorial Award.

Climate Change Impacts on the Snake River Plain's Surface & Ground Water Resources

Basic Information

Title:	Climate Change Impacts on the Snake River Plain's Surface & Ground Water Resources
Project Number:	2008ID99B
Start Date:	3/1/2008
End Date:	2/28/2010
Funding Source:	104B
Congressional District:	First
Research Category:	Climate and Hydrologic Processes
Focus Category:	Climatological Processes, Surface Water, Groundwater
Descriptors:	
Principal Investigators:	Russell J. Qualls

Publication

Regional economic demand for irrigation water
in Idaho's Eastern Snake River Plain

Leven Elbakidze and Garth Taylor

Exploding municipal, energy, and environmental water demands are in collision with limited or declining water supplies. With agriculture being the largest (over 80%) water user in the West, agricultural water supplies are targeted as the least cost water source to meet emerging demands. Precise estimation of irrigation water demand is critical to evaluate water reallocation and other issues such as climate change, new storage or conveyance, water markets, and groundwater banking. The case study for this research is Idaho's Snake River Plain where aquifer levels are dropping as a result of improved irrigation efficiency and pumping by junior water right holders creating shortages for senior water users. Idaho Department of Water Resources and US Bureau of Reclamation (BOR) are studying options including ground water banking, off-season canal recharge, water buyouts or leases and curtailment of groundwater pumpers to remedy shortages in the Eastern Snake Plain Aquifer and prevent damages to senior right holders. This study was done using data from both Jerome and Gooding counties in Southern Idaho whose irrigators consume water from the Eastern Snake River Plain Aquifer.

Water distribution related research and policy require accurate and accessible region specific irrigation demand functions and elasticities. The price elasticity of demand for irrigation water can be a key piece of information for evaluating water reallocation projects. These demand functions and elasticities have long been measured econometrically but these types of studies lack area specificity, are costly and time consuming to estimate and range from inelastic to elastic (Scheierling, Loomis, and Young, 2004). On the other hand demand derived based on maximizing regional agricultural revenues provides the needed specificity. This project estimates the demand for irrigation water using the shadow price of water. While other projects have measured a short run demand curve for irrigation water, this model is based on the longer run. This model not only allows for the short run substitution between crops, but it also allows the entire portfolio of crops grown to change. This model also accounts for soil portfolio changes along with irrigation technology changes. The project results in demand elasticities of irrigation water that can be used for various purposes across southern Idaho.

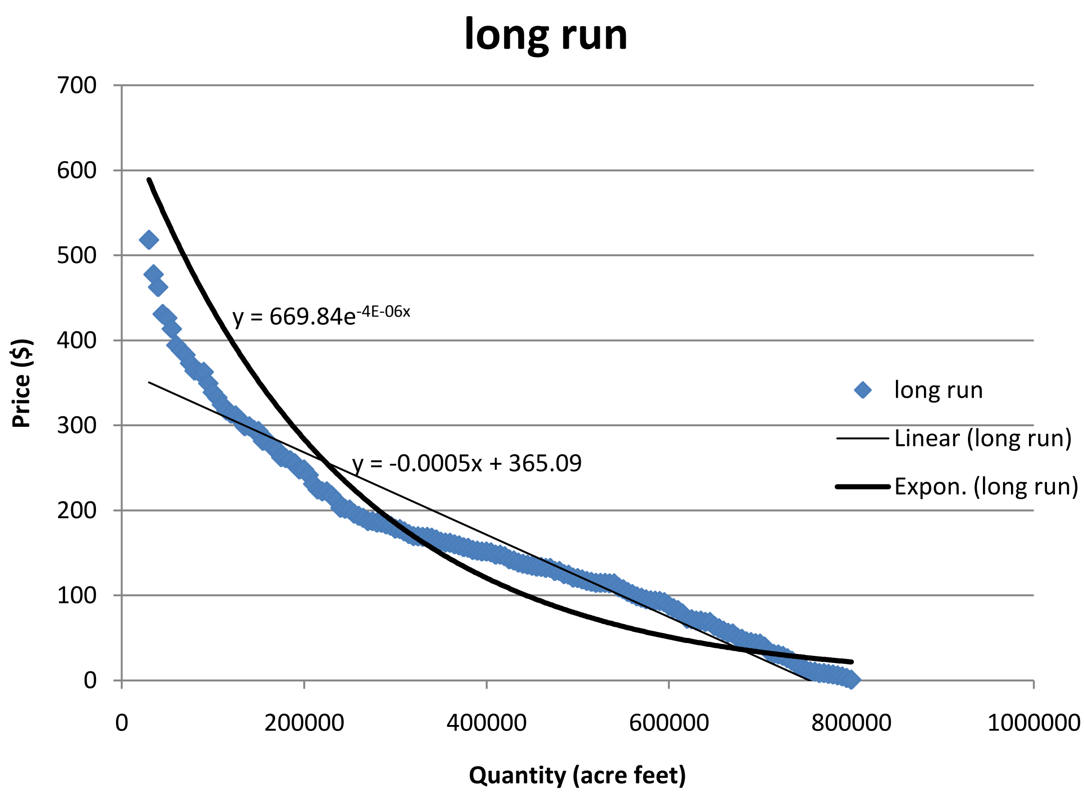
The case study for this project was the southern Idaho counties of Gooding and Jerome. The crops in the study area and thus used in the model are barley, dry beans, corn for grain, corn for silage, forage, pasture, potatoes, sugarbeets, and wheat. These crops comprise roughly 95% of the irrigated land in Gooding and Jerome counties. To account for different yields due to soil type that the crop is grown in, all production function coefficients had to be calculated for each crop-soil type combination. The underlying production function [1]:

$$Y= Yd+(Ym - Yd)(1-(1-I/Im)^{(1/B)}) \text{ where } B=(ETm-ETd)/Im$$

To populate the production function, data was obtained or calculated for dry land yield of crop (Yd), maximum yield of fully irrigated crop (Ym), depth of irrigation required to produce maximum yield for each crop (Im), maximum evapotranspiration of each crop (ETm), and dry land evapotranspiration of each crop (ETd).

The preliminary results show a downward sloping long run demand curve (Figure 1) for irrigation water in Gooding and Jerome counties. The demand point-elasticities are fairly inelastic at high prices and very elastic at lower prices for this long run demand curve. The preliminary results for the short run demand curve in these two counties is very similar to the results gained from the long run.

[1] Martin, D. et al Evaluation of Irrigation Planning Decisions. Journal of Irrigation and Drainage Engineering. Vol. 115, No. 1, February 1989. 58-77.



Information Transfer Program Introduction

During the 2008 Program Year, 104B program and state funds were used to support the Idaho Water Resources Research Institute Information and Technology Transfer Program. This program includes efforts to reach all water resource stakeholders in the state, from K to Grave. These efforts included; Water Education Workshops for Teachers (300 teachers were trained in 12 workshops across Idaho); a groundwater connections workshop in Boise (180 attendees); groundwater protection workshops for local governments that were held in Caldwell, Moscow, Twin Falls, Pocattelo and Idaho Falls; Youth events across the state which include Water Awareness week (over 10,000 attendees), Youth Water Festivals in Moscow and Weiser (50 attendees) and Salmon and Steelhead Days held in Boise; and a state wide water resources seminar series delivered via a compressed video system to Boise, Moscow, Pocatello, Idaho Falls and Coeur d'Alene (20 seminars during the year with an average attendance in all locations of 35 people per seminar).

In addition, during the 2008 Program Year, training opportunities for water professionals were expanded through initiated interactions with the newly developed Boise Watershed Center. IWRRI also worked with faculty from the University of Idaho to help secure a $3 million NSF K-12 education grant focused on integrating water resources education in Idaho's public school system. The IWRRI also developed or sponsored four water resources workshops, conferences and symposia focusing on specific water resources issues of interest across the state, region and nation. These meetings were: the Univesity of Idaho's Presidents Sustainability Symposia focused on Sustainable Water Resources Infrastructure, held in Boise, ID in October of 2008; The Palouse Water Summit, held in Moscow, ID, in October 2008; Idaho Water Users Conference, held in Boise, ID in January 2009; and a workshop on No Adverse Impact Floodplain and Stormwater Management, held in Eagle, Idaho in February of 2009. Finally, the IWRRI helped initiate a state chapter of the American Water Resoruces Association for Idaho by sponsoring the initial meeting in April of 2009.

In addition to these activities, one Information Transfer project was ongoing during the 2008 Program Year that developed a tool for determining components of the water balance for the Snake River Plain, which is currently undergoing the largest water rights adjudication effort in the United States. This tool is now being made available for use through a University of Idaho portal by water management entities and water users throughout Idaho and the intermountain west regon.

A spreadsheet tool to derive economic demand for irrigation water from crop price, evapotranspiration/yield relationships and irrigation application efficiency

Basic Information

Title:	A spreadsheet tool to derive economic demand for irrigation water from crop price, evapotranspiration/yield relationships and irrigation application efficiency
Project Number:	2007ID78B
Start Date:	3/1/2007
End Date:	12/30/2008
Funding Source:	104B
Congressional District:	01 & 02
Research Category:	Social Sciences
Focus Category:	Economics, Water Supply, Irrigation
Descriptors:	
Principal Investigators:	Bryce Contor, Richard Allen, Garth Taylor

Publication

1. Idaho Water Resources Research Institute technical report 200803, "Spreadsheet Tool for Estimating Economic Demand for Irrigation Water Using Commodity Prices and Evapotranspiration Production Functions: IDEP" is in final review with the co-investigators. It will be accompanied by an English-units and SI-units version of the tool.

Statement of regional or State water problem.
The population of Idaho and other western states continues to grow, creating new demands for water supplies including supplies of potable water. Surface-water sources have been fully allocated for decades, and realization is growing that with the hydrologic connections that exist between ground-water and surface-water, developing ground-water supplies often impacts existing surface-water uses. Consequently, developing new potable water supplies will require moving existing water supplies to new uses. Interest is growing in exploring market mechanisms to facilitate these changes.

Idaho Department of Water Resources and US Bureau of Reclamation are working on economic modeling of water transactions in the Boise valley. IWRRI and US Bureau of Reclamation are studying ground-water banking in the Eastern Snake Plain Aquifer. These and similar economic studies require knowledge of the demand for water for irrigation. Because irrigators often face a supply based on water availability, water rights, and contracts (rather than market forces) and because charges paid by irrigators are simply delivery charges (often subsidized), it is difficult to extract demand information from market transactions. An alternate way to calculate demand is by examining water's role as an input to the production of agricultural commodities. Methodologies exist to perform these calculations, but they have not been assembled and linked in an easily-applied application.

Statement of results or benefits.
The result of the project will be a spreadsheet tool that applies established and accepted algorithms, methodologies and field-tested, peer-reviewed data to calculate a water-demand function for production of a given crop in a given location. The market price of the crop will be an input to the spreadsheet, along with local data to parameterize calculations of evapotranspiration production functions and irrigation application efficiency. Accompanying documentation will review the literature on the available calculation methodologies, discuss uses and limitations of the tool, and discuss considerations for users to verify local results. An article describing the tool and the method will be submitted to the journal <u>Agricultural Water Management</u>.

Nature, scope, and objectives of the project.
This is an information-transfer project designed to make available and link existing methodologies. The scope is to develop estimates of economic demand for irrigation water for the western USA, but it is expected that the tool will be applicable world-wide. The objectives are to produce: a) A functional spreadsheet tool; b) Project documentation and users' manual; and c) A peer-reviewed journal article.

The approximate time-line is as follows:

June 2007	Confer with co-investigators on approach and relevant literature. Literature search and review.
July 2007	Select algorithms and methods. Construct spreadsheet tool.
August 2007	Finalize, test and review spreadsheet tool.

Fall 2007	Write project documentation, users' manual and draft journal article.
Dec. 2007	Submit journal article.

Methods, procedures and facilities.

Methods: Existing methods for estimating water production functions require costly field experiments (Hexem and Heady 1978) or data-intensive modeling (Williams et al 1989). These methods also produce site-specific results. However, ET production functions are theoretically site independent (Liu 2002), which is confirmed with experimentally-derived ET production functions (Sammis 1981). Because ET production functions are site independent, they will be used to develop site-specific applied-water production functions using the simple relationship (applied water = (ET-P_e)/irrigation application efficiency) using local data..

Existing algorithms for evapotranspiration production functions and irrigation application efficiency will be combined algebraically and deployed in a spreadsheet application. The application will use price and yield to calculate revenue, and the first derivative of revenue with respect to application depth will be used to represent the marginal production value of water, which is equal to irrigators' production demand for water. Equations and methods will be refined based on a literature search, but equations (1) through (3) can be considered conceptually to illustrate the manipulation of input algorithms:

$$\text{Yield} = b_0 + b_1(\text{Evapotranspiration}) \qquad (1)$$

$$\text{Evapotranspiration} = (A)(E_a) \qquad (2)$$

A = depth of irrigation application

E_a = irrigation application efficiency

$$E_a = 1/\,(b_2A + b_3) \qquad (3)$$

Equations (1) and (2) are frequently cited in the literature. Equation (3) is hypothetical at this point but consistent with the physical processes that control application efficiency. If b_3 is near 1.0, equation (3) has the property that efficiency is very high at small application depths, decreases with increased application depth, and is asymptotic to zero at large depths. Equation (3) may be substituted into equation (2) and the result into equation (1) to obtain a relationship between yield and application depth:

$$\text{Yield} = b_0 + b_1A/(b_2A + b_3) \qquad (4)$$

Equation (4) shows decreasing marginal returns to irrigation as depth increases, though it does not show the negative marginal return at very large depths which is typical of experimentally-derived water production functions. However, this range of the water production function is not of interest because rational producers will not enter this region. Multiplying yield times price gives revenue. Taking the first derivative of revenue with respect to application depth gives the marginal production value (irrigators' demand) for irrigation water:

$$dR/dA = Pb_1b_3/((b_2A + b_3)^2) \quad (5)$$

R = Revenue
P = Price

Procedures: A literature search will be used to identify appropriate equations similar to the sample equations illustrated, along with peer-reviewed experimentally based yield-ET data and functions. A spreadsheet will be constructed to solicit user input to populate site-specific parameters and produce various outputs. The spreadsheet will be reviewed conceptually and tested practically with simulated and literature-obtained data.

Facilities: The work will be conducted at the IWRRI office in Idaho Falls, at the Moscow campus of University of Idaho and at the Kimberly Research and Extension Center. At all three facilities, researchers have access to adequate computers and software, high-speed internet connections and subscriptions to library data services. In addition, the Moscow investigator has direct physical access to the University library. All investigators have access to colleagues expert in computer science, mathematics, economics and agronomy.

Related research.

Irrigation application efficiency:

Howell, T.A., *Enhancing Water Use Efficiency in Irrigated Agriculture,* Agronomy Journal 93 part 2 (2001): 281-285

Burt, C.M., A.J. Clemmens, T.S. Strelkoff, K.H. Solomon, R.D. Bliesner, L.A. Hardy, T.A. Howell and D.E. Eisenhauer, *Irrigation Performance Measures: Efficiency and Uniformity*, Journal of Irrigation and Drainage Engineering November/December 1997.

Prajamwong, S., G.P. Merkley and R.G. Allen, *Decision Support Model for Irrigation Water Management,* Journal of Irrigation and Drainage Engineering March/April 1997

E.A. Ross and J.D. Hedlund, *Farm Irrigation Rating Index (FIRI) - A Procedure to Evaluate Both Irrigation Systems and Management*, Irrigation and Drainage 1991

Water Production Functions, Evapotranspiration Production Functions:

Zwart, S.J. and W.G.M. Bastiaansen, *Review of Measured Crop Water Productivity Values for Irrigated Wheat, Rice, Cotton and Maize,* Agricultural Water Management 69 (2004): 115-133.

Liu, W.Z., D.J. Hunsaker, Y.S. Li, X.Q. Xie and G.W. Wall, *Interrelations of Yield, Evapotranspiration, and Water-use Efficiency from Marginal Analysis of Water Production Functions,* Agricultural Water Management 56 (2002): 143-151

Williams, J.R., C.A. Jones, J.R. Kiniry and D.A. Spanel, *The EPIC Crop Growth Model*, Transactions of the ASAE Vol 32 (2) March-April 1989

T.W. Sammis, *Yield of Alfalfa and Cotton as Influenced by Irrigation,* Agronomy Journal 1981

Hexem, R.G. and E.O. Heady, Water Production Functions for Irrigated Agriculture. Iowa State University Press, 1978.

Yield, Evapotranspiration and Water Value:

Grismer, M.E., *Regional Alfalfa Yield, ETc, and Water Value in Western States,* Journal of Irrigation and Drainage Engineering, May/June 2001.

The literature provides adequate basis for calculation of ET production functions and irrigation application efficiency, and adequate comparisons to applied-water production functions to test derived relationships. Some studies also integrate economic and price factors, but they tend to take price and/or demand for water as given (see Liu and Grismer, for instance). The unique contribution of the proposed work is to derive demand from production functions, in order to discover expected irrigator behavior in market transactions where price is influenced by market forces.

Training potential. One student will receive training in this project. It is expected that this will be a BS student.

Investigator's qualifications.

Bryce A. Contor
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(208) 681 9100

Experience

2004 - Current	Research Hydrologist, Idaho Water Resources Research Institute, University of Idaho, Idaho Falls, Idaho. Position includes serving as a principle investigator on a ground water banking project in cooperation with U.S. Bureau of Reclamation and as a principle investigator on an evapotranspiration study with the USGS Water Institutes 104b program. Position also includes water-budget preparation for ground-water modeling projects in the Eastern Snake Plain Aquifer and the Spokane Valley-Rathdrum Prairie Aquifer.
2003 - 2006	Owner, Water Resources Field Services LLC. Services included water-right field mapping, GIS and GPS mapping, and contract adjudication claims field inspections.
2001 - 2004	Senior Scientific Aide, Idaho Water Resources Research Institute, University of Idaho, Idaho Falls. Position included primary responsibility for development of a water budget for the Eastern Snake Plain Aquifer in support of a regional modeling effort. This included heavy utilization of ESRI GIS products and minor Visual Basic computer programming.
1999 - 2001	Senior Water Resource Agent, Idaho Department of Water Resources, Idaho Falls, Idaho. Duties entailed evaluation of water-right claims and making water-right recommendations in the Snake River Basin Adjudication.
1997 - 1999	Water Resource Agent, North Water Measurement District, Idaho Falls, Idaho. The primary duty was the measurement of water discharge and power consumption of irrigation wells for estimation of ground water withdrawal volumes. Secondary duties related to data reporting and the development and testing of alternate methods for determining withdrawal volumes.
1996	Technician, Idaho Department of Water Resources, Boise, Idaho. Measurement of water discharge and power consumption, and calibration of measuring devices, for irrigation and commercial wells.
1980 - 1995	Employed in production agriculture in Oregon and Idaho

Education

2005	M.S., Hydrology, University of Idaho, Moscow ID
1996	One-year certificate, Water Resource Management, College of Southern Idaho, Twin Falls ID
1994	B.S., Agricultural Economics, Brigham Young University, Provo, UT
1980	Specialized Associate, Farm Crops Production, Ricks College, Rexburg ID

Publications

2006	*Ground-water Banking in the Eastern Snake Plain Aquifer*, <u>Ground Water and Surface Water Under Stress: Competition, Interaction, Solutions.</u> 2006. US Committee on Irrigation and Drainage. RD Schmidt, co-author.
2004	*Ground Water Right Transfers In the Snake River Plain, Idaho*, in <u>The Water Report,</u> December 15, 2004. Gary S. Johnson, primary author.
2002 - 2004	Eastern Snake Plain Aquifer Model Enhancement Project technical reports. These may be viewed at http://www.if.uidaho.edu/~johnson/ifiwrri/projects.html
1997	<u>PSI Method for Determining Annual Pumpage Volume of Diversions in the North Water Measurement District</u>. Unpublished report to Idaho Department of Water Resources.
1992	*When to Plow Alfalfa: A Present-value Approach*. <u>Hay and Forage Grower Magazine</u>, March 1992.

RICHARD GLEN ALLEN
Water Resources Engineering Professor

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DEPT. BIOLOGICAL AND AGRICULTURAL ENGINEERING

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AREAS OF SPECIALIZATION:
Hydrology and Water Resources – Surface and Subsurface Systems, Remote Sensing
Evapotranspiration – Measurement, Remote Sensing, Calculation, Energy Balance, Wetlands, Crop Water Requirements, Electronic Instrumentation
Irrigation – Water Management, Demands, System Design, Soil Water – Flow Processes

DEGREES:
B.S. Agricultural Engineering, Iowa State University, November 1974
M.S. Agricultural Engineering, University of Idaho, June 1977
Ph.D. Civil Engineering, University Idaho, May 1984

PROFESSIONAL REGISTRATION:
Civil Engineer, State of Idaho, #4351, July 1981

PROFESSIONAL POSITIONS:
Professor of Civil Engineering and Bio. and Agr. Engineering, Dec. 1998 to pres., Univ. Idaho.
Member, Landsat Science Team, Nat. Aeronautics and Space Admin. and USGS, 2006-2011
Professor, Bio. and Irrigation Engineering, May 1998 to Dec. 1998, Utah State Univ.
Assist./Assoc. Prof, Bio, and Irrig, Engineering, Jan, 1986 to April 1998, Utah State Univ.
Assist. Prof. Civil Engineering, Jan. 1984 to Dec. 1985, Iowa State Univ., Ames, IA.
Research Assoc., May 1977 to Dec. 1983, Univ. Idaho, Kimberly Res. and Ext. Center.

PUBLICATIONS:
70 Papers in **Refereed Journals/Chapters** - primary author on 34
103 Nonrefereed Professional Engineering Papers - primary author on 58
33 Technical Research Completion Reports - primary author on 24

ORGANIZATIONS:
American Society of Civil Engineers: ***Evapotranspiration Technical Committee***
Consortium of Universities for the Advancement of Hydrologic Science (CUAHSI)
International Commission on Irrigation and Drainage ***(working group on sustainable crops)***
U.S. Committee on Irrigation and Drainage, American Geophysical Union
Irrigation Association ***(technical committee on water management)***

AWARDS

ASCE State-of-the-Art of Civil Engineering Award, 1992. *ASCE Manual 70: Evapotranspiration.*

ASCE 2003 Royce J. Tipton Award, *"For outstanding contributions…through system simulation, software development, teaching, and research and for advancements in the knowledge of evapotranspiration theory and concepts for world-wide application."*

United States Committee on Irrigation and Drainage 'Service to the Profession Award,' 2003.

ASCE Arid Lands Hydraulic Engineering Award, *2005.*

Outstanding Journal Paper Award, American Society of Civil Engineers, Journal of Irrigation and Drainage Engineering. 1987. (*A Penman for All Seasons,* R.G.Allen, 1986, 112(4):348-368).

Outstanding Journal Paper Award, American Society of Civil Engineers, Journal of Irrigation and Drainage Engineering. 1997. (*Assessing Integrity of Weather Data for use in Reference Evapotranspiration Estimation,* R.G. Allen, 1996, 122(2):97-106).

Best Paper Award, American Society of Civil Engineers, Journal of Hydrologic Engineering. 1999. *(Translating Wind Measurements from Weather Stations to Agricultural Crops,* R.G. Allen and J.L. Wright, 1997, 2(1): 26-35*).*

Excellence in Teaching, Bio. and Irrig. Engrg, Utah State Univ., 1992; ***Outstanding Researcher***, Bio. and Irrig. Engrg, Utah State Univ., 1996; ***Excellence in Research***, College of Engineering, Utah State Univ., 1996; ***Top Professor***, Utah State Univ. Mortar Board, 1998

RECENT RELATED JOURNAL PUBLICATIONS:

Allen, R.G. 2004. Penman-Monteith Equation. Entry in the Encyclopedia of Soils in the Environment. Elsevier Ltd., Oxford, U.K. ©2005 ISBN 0-12-348530-4, Vol. 3:180-188.

Tasumi, M., R. G. Allen, R. Trezza, J. L. Wright. 2005. Satellite-based energy balance to assess population variance of crop coefficients, *J. Irrig. Drain. Engrg,* ASCE 131(1):94-109.

Allen, R.G., Clemmens, A.J., Burt, C.M., Solomon, K., and O'Halloran, T. 2005. Prediction Accuracy for Project-wide Evapotranspiration using Crop Coefficients and Reference Evapotranspiration. *J. Irrig. and Drain. Engrg,* ASCE 131(1):24-36..

Bastiaanssen , W.G.M., E.J.M. Noordman , H. Pelgrum, G. Davids, B.P. Thoreson and R.G. Allen. 2005. SEBAL model with remotely sensed data to improve water resources management under actual field conditions. *J. Irrig. and Drain. Engrg,* ASCE 131(1):85-93.

Burt, C. M., Mutziger, A.J., Allen, R.G. and Howell, T.A. 2005. Evaporation Research: Review and Interpretation *J. Irrig. and Drain. Engrg,* ASCE 131(1):37-58.

Tasumi, M., R. Trezza , R.G. Allen and J. L. Wright. 2005. Operational aspects of satellite-based energy balance models for irrigated crops in the semi-arid U.S. *J. Irrig. Drain. Sys.* 19: 355-376.

Allen, R.G., M.Tasumi, A.T. Morse, and R. Trezza. 2005. A Landsat-based Energy Balance & Evapotranspiration Model in Western US Water Rights Regulation and Planning. *J. Irrig. Drain. Sys.* 19:251-268.

De Bruin, H.A.R., O.K. Hartogensis, R.G. Allen and J.W.J.L. Kramer. 2005. Regional advection perturbations in an irrigated desert (RAPID) experiment. *Theor. and Applied Climatology* 80:143-152

Allen, R.G., A. Morse, M. Tasumi, W.J. Kramber and W.G.M. Bastiaanssen, 2005. Chapter 5 "Computing and Mapping of Evapotranspiration". In: *Advances in Water Science Methodologies*, Taylor and Francis, The Netherlands.

Allen, R.G., W.O. Pruitt, J.L. Wright, et al.,. 2005. A recommendation on standardized surface resistance for hourly calculation of reference ETo by the FAO56 Penman-Monteith method. *Agric. Water Man*. 81:1-22.

Allen, R.G., M. Tasumi, A.T. Morse, R. Trezza, W. Kramber, I. Lorite and C.W. Robison. 2006. Satellite-based energy balance for mapping evapotranspiration with internalized calibration (METRIC) – Applications. ASCE *J. Irrigation and Drainage Engineering* (in press).

Allen, R.G., R. Trezza and M. Tasumi. 2006. Analytical integrated functions for daily solar radiation on slopes. *Agricultural and Forest Meteorology*. (in press).

R. G. TAYLOR, PhD

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KEY EXPERIENCE

Economics Instructor — Taught graduate and undergraduate economics and business courses, workshops and short courses.

Research Economist — Quantitative economic analysis and econometrics researcher and successful grant writer, author of research publications, professional presentations and journal referee.

Extension Economist — Extension emphasis in resource policy and management, regional economic development and agribusiness. Working with governments, agricultural producers, businesses and extension educators.

Consulting Economist — Consulting projects emphasized quantitative and econometric solutions for policy or regulatory issues for Fortune 500, agricultural producer organizations, local and federal government, and international organizations.

EDUCATION

Ph. D. — Agricultural and Resource Economics, Colorado State University. **1991**

M.S. and B.S. — Range Resource Economics, Utah State University.

EMPLOYMENT

Associate Professor
University of Idaho
1998 to present

Department of Agricultural Economics, University of Idaho. Extension and research responsibilities in rural economic development, agriculture and resources economics.

Extension

- **Idaho Regional Economics**

Research

Water Policy and Management Research. Obtained grants and published research on regional impacts of water policy:
Regional Input-Output and Community Models. Researched techniques to modify IMPLAN for small resource based regional economies.
Tourism and Travel. Developed regional I/O models to assess tourism and travel impacts. Recreation survey to value and ascertain impacts.

Teaching & Advising

Major advisor MS and PhD students and teaches one course in Project Evaluation.

Assistant Professor University of Nebraska 1992 to 1998	College of Business Administration and Department of Agricultural Economics, University of Nebraska Taught and administered the Masters of Business Administration distance education program coupled with extension responsibilities in rural economic development, agriculture and resources economics .
Economist 1991 to 1992	Department of Interior Bureau of Land Management, Cheyenne WY. Industry Economist on an interdisciplinary mineral evaluation team with engineers, geologists, and appraiser.

Refereed Journals and Book Chapter(s)

2. Foltz, John, Stacie Woodall Philip Wandschneider and R. G. Taylor The Contribution of the Grape and Wine Industry to Idaho's Economy - Agribusiness and Tourism Impacts. Journal of Agribusiness Vol. 25 No. 1; 2007.

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5. McKean, John R. Donn Johnson, and R. G. Taylor. Willingness to Pay for Non Angler Recreation at the Lower Snake River Reservoirs. Journal of Leisure Research 2005 Vol. 37 (2) 178-194.

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7. R. G. Taylor, John R. McKean, and Robert A. Young "Alternate Price Specifications for Estimating Residential Water Demand with Fixed Fees." Land Economics Aug. 2004.

8. Taylor, R. G. and Robert A. Young. "Rural to Urban Water Transfers: Measuring Foregone Regional Irrigation Water Benefits Under Uncertain Water Supplies". Economics of Water Resources: Institutions, Instruments and Policies for Managing Scarcity edited by K. William Easter and Mary Renwick. Ashgate Publishing, London, UK. Feb. 2004.

9. McKean, J. R., D. Johnson, and R. G. Taylor, Measuring demand for flat water recreation using a two-stage/disequilibrium travel cost model with adjustment for overdispersion and self-selection. Water Resources Research, 39(4), 1107, doi:10.1029/2002WR001644, 2003.

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14. Michelsen, Ari M., R. G. Taylor, Thomas McGuckin and Ray Huffaker. "Emerging Agricultural Water Conservation Price Incentives." Journal of Agriculture and Resource Economics. 24(1):222-238 1999.

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Regional Economic Demand for Irrigation Water in Idaho's Eastern Snake River Plain

Basic Information

Title:	Regional Economic Demand for Irrigation Water in Idaho's Eastern Snake River Plain
Project Number:	2008ID132B
Start Date:	3/1/2008
End Date:	2/28/2009
Funding Source:	104B
Congressional District:	1st & 2nd
Research Category:	Social Sciences
Focus Category:	Economics, Water Supply, Irrigation
Descriptors:	
Principal Investigators:	Garth Taylor, Levan Elbakidze

Publication

Regional economic demand for irrigation water in Idaho's Eastern Snake River Plain

Leven Elbakidze and Garth Taylor

Exploding municipal, energy, and environmental water demands are in collision with limited or declining water supplies. With agriculture being the largest (over 80%) water user in the West, agricultural water supplies are targeted as the least cost water source to meet emerging demands. Precise estimation of irrigation water demand is critical to evaluate water reallocation and other issues such as climate change, new storage or conveyance, water markets, and groundwater banking. The case study for this research is Idaho's Snake River Plain where aquifer levels are dropping as a result of improved irrigation efficiency and pumping by junior water right holders creating shortages for senior water users. Idaho Department of Water Resources and US Bureau of Reclamation (BOR) are studying options including ground water banking, off-season canal recharge, water buyouts or leases and curtailment of groundwater pumpers to remedy shortages in the Eastern Snake Plain Aquifer and prevent damages to senior right holders. This study was done using data from both Jerome and Gooding counties in Southern Idaho whose irrigators consume water from the Eastern Snake River Plain Aquifer.

Water distribution related research and policy require accurate and accessible region specific irrigation demand functions and elasticities. The price elasticity of demand for irrigation water can be a key piece of information for evaluating water reallocation projects. These demand functions and elasticities have long been measured econometrically but these types of studies lack area specificity, are costly and time consuming to estimate and range from inelastic to elastic (Scheierling, Loomis, and Young, 2004). On the other hand demand derived based on maximizing regional agricultural revenues provides the needed specificity. This project estimates the demand for irrigation water using the shadow price of water. While other projects have measured a short run demand curve for irrigation water, this model is based on the longer run. This model not only allows for the short run substitution between crops, but it also allows the entire portfolio of crops grown to change. This model also accounts for soil portfolio changes along with irrigation technology changes. The project results in demand elasticities of irrigation water that can be used for various purposes across southern Idaho.

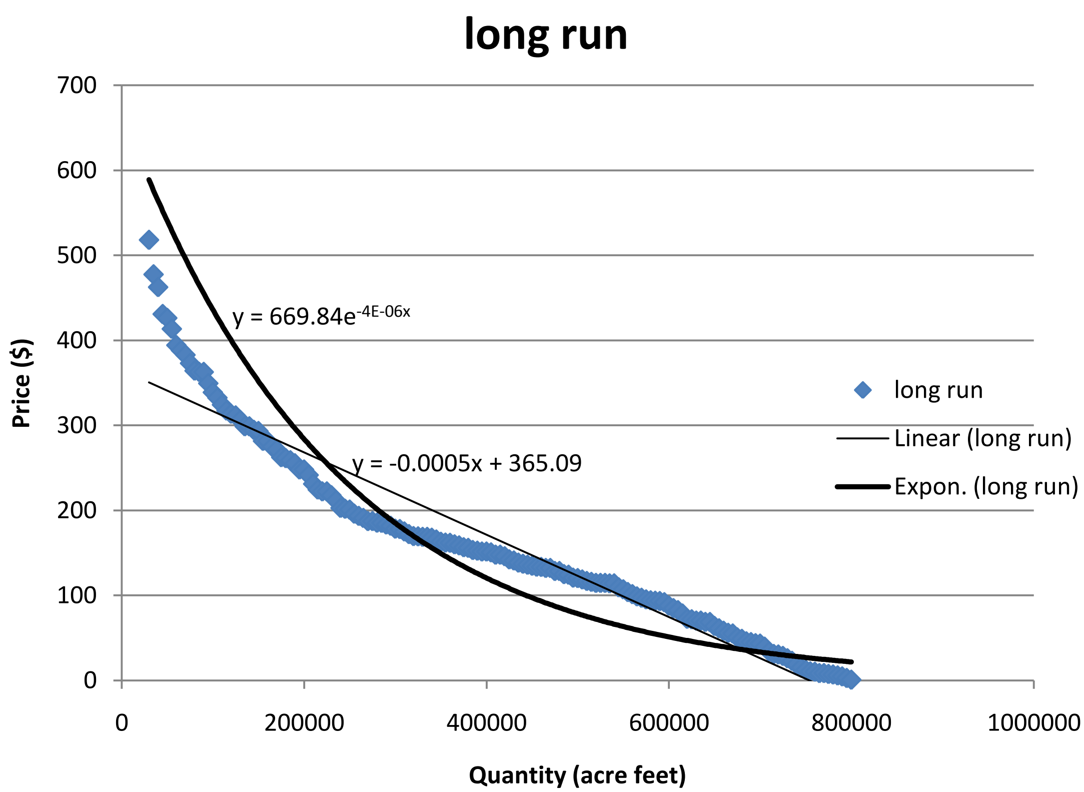
The case study for this project was the southern Idaho counties of Gooding and Jerome. The crops in the study area and thus used in the model are barley, dry beans, corn for grain, corn for silage, forage, pasture, potatoes, sugarbeets, and wheat. These crops comprise roughly 95% of the irrigated land in Gooding and Jerome counties. To account for different yields due to soil type that the crop is grown in, all production function coefficients had to be calculated for each crop-soil type combination. The underlying production function [1]:

$$Y = Yd+(Ym - Yd)(1-(1-I/Im)^{(1/B)}) \text{ where } B=(ETm-ETd)/Im$$

To populate the production function, data was obtained or calculated for dry land yield of crop (Yd), maximum yield of fully irrigated crop (Ym), depth of irrigation required to produce maximum yield for each crop (Im), maximum evapotranspiration of each crop (ETm), and dry land evapotranspiration of each crop (ETd).

The preliminary results show a downward sloping long run demand curve (Figure 1) for irrigation water in Gooding and Jerome counties. The demand point-elasticities are fairly inelastic at high prices and very elastic at lower prices for this long run demand curve. The preliminary results for the short run demand curve in these two counties is very similar to the results gained from the long run.

[1] Martin, D. et al Evaluation of Irrigation Planning Decisions. Journal of Irrigation and Drainage Engineering. Vol. 115, No. 1, February 1989. 58-77.



USGS Summer Intern Program

None.

Student Support					
Category	**Section 104 Base Grant**	**Section 104 NCGP Award**	**NIWR-USGS Internship**	**Supplemental Awards**	**Total**
Undergraduate	2	0	0	0	2
Masters	2	0	0	1	3
Ph.D.	1	0	0	0	1
Post-Doc.	0	0	0	0	0
Total	5	0	0	1	6

Notable Awards and Achievements

For Project 2007ID 78B, Co-investigator Garth Taylor showed a prototype version of the tool to the organizers at the Western Agricultural economics conference in Montana in June 2008 and was invited to present an impromptu session on the tool for water economists at the conference. In addition, the tool developed in this project is being made available to water users and water managers through the University of Idaho's technical transfer web-portal, and should be available for use in the fall of 2009.

For Projet 2008ID 129B, Cindy J. Adams has received 2 scholarships related to her thesis project on this grant. The first being the Environmental Science Program Graduate Interdisciplinary Enhancement Fund (GIEF) and the second being the Braatne Memorial Award at the University of Idaho.

Based on some of the research completed under project 2008ID 99B, Dr. Qualls was invited to present portions of his work to the Idaho Senate and House of Representatives' Agricultural Affairs Committees and their respective committees.